MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

EOP3046 – OPTICAL WAVEGUIDE AND DEVICES

(OPE)

07 OCTOBER 2016
9:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTION TO STUDENT

1. This Question paper consists of **5** pages with **4** Questions only.

2. Attempt **ALL FOUR** questions. The questions do not carry the same marks distribution. The marks distribution for each question is given at the end of every question.

3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) Consider a plane wave type of light ray propagating in the dielectric slab waveguide as shown in Figure Q1(a). The ray is reflected at B and C, just after reflection at C, the wavefront at C overlaps the wavefront at A on the original ray. Here the wave interferes with itself, unless if it is in phase, the two will interfere destructively and destroy each other. Show that the waveguide condition that shows only certain reflection angle give rise to the constructive interference and hence only certain waves can exist in the guide is given by

$$\left(\frac{2\pi n_1(2a)}{\lambda}\right)\cos\theta_m - \phi_m = m\pi$$

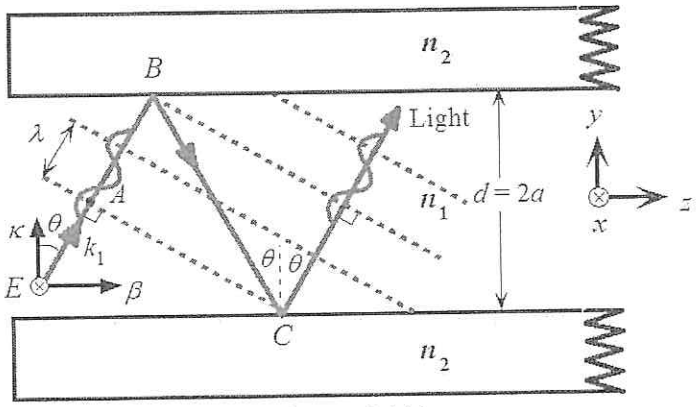

Figure Q1(a)

[7 marks]

(b) Consider the reflection of light on a boundary between a glass medium of refractive index 1.46 and air of refractive index 1.

i. If light is travelling from air to glass at normal incidence angle, what are the reflection coefficient and the intensity of the reflected light with respect to that of the incident light?

[2 marks]

ii. What is the polarization angle?

[1 mark]

Continued...

Question 2

(a) Besides guided modes, describe two types of unguided modes that can be found in optical waveguides.

[2 marks]

(b) Figure Q2(b) shows intensity patterns of three different modes in a multimode optical fibre. Label them appropriately.

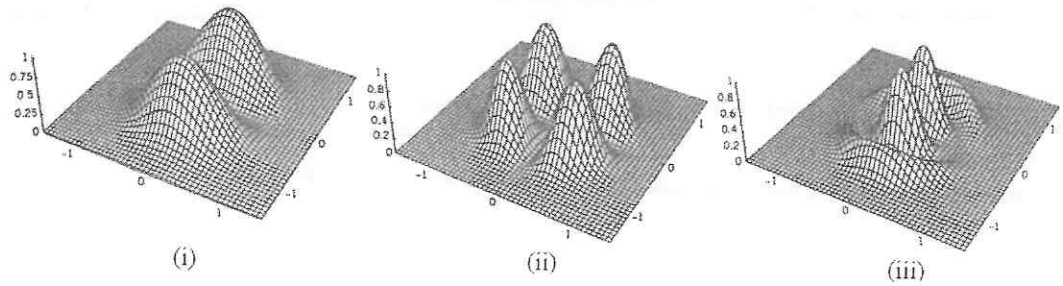

Figure Q2(b)

[3 marks]

(c) What should be the minimum operating wavelength for a symmetrical step index planar waveguide so that it supports only the fundamental TE mode? Take core refractive index, $n_1 = 3.6$, cladding refractive index, $n_2 = 3.56$ and core thickness, $d = 7.8$ μm.

[3 marks]

(d) A multimode step-index fibre has a relative refractive index difference of 2% and a core refractive index of 1.5. The number of modes propagating at a wavelength of 1.3 μm is 1000. Calculate the diameter of the fibre core.

[3 marks]

(e) Consider a multimode fibre with a core diameter of 10 μm, core refractive index of 1.46 and a cladding refractive index of 1.45 both at a wavelength of 850 nm. Calculate the wavelength beyond which the fibre becomes single mode and the numerical aperture.

[3 marks]

(f) Briefly describe material dispersion, waveguide dispersion, intermodal dispersion and polarization mode dispersion.

[4 marks]

(g) Describe the origin of *Stimulated Brillouin Scattering* (SBS). In addition, describe how it can affect transmission in optical fibre.

[2 marks]

Continued...

Question 3

(a) You are asked to design an *Acousto-Optics Tunable Filter* (AOTF). Describe a possible design to be used with the help of a diagram. [6 marks]

(b) Assume that the input wavelengths of a 2 x 2 silicon MZI are separated by 10 GHz (i.e. $\Delta\lambda = 0.08$nm at 1550nm), with $n_{eff} = 1.5$ in a silicon waveguide. Calculate the necessary waveguide length difference for multiplexing operation. [2 marks]

(c) Design a 4 x 4 multiplexer using combination of basic 2 x 2 MZIs. Show that the length difference of the interferometer arms in the second stage is equal to the length difference of the interferometer arms in the first stage. [7 marks]

Question 4

(a) With the help of diagrams, describe three possible methods for depositing alloy films using evaporation. [7 marks]

(b) State the FOUR advantages of sputtering technique over evaporation technique. [4 marks]

(c) Give TWO examples of dopant that can increase the refractive index and TWO examples of dopant that can decrease the refractive index of pure silica in optical fibre fabrication. [4 marks]

Continued...

Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

End of paper.